PENECONTEMPORANEOUS EROSIONAL SLUMP STRUCTURE NEAR MINERAL CITY, OHIO

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Complex structural disturbance of Pennsylvanian sedimentary rocks near Mineral City, Ohio, is interpreted as the result of slumping of partially consolidated sediments into a valley of Pennsylvanian age and burial by later Pennsylvanian sediments which are undisturbed. Study of such structures is of value to both the coal and petroleum industries as well as to stratigraphers and sedimentologists.

The area discussed is located in northeastern Tuscarawas County, Ohio, near Mineral City, in Sandy Township (fig. 1). The structure is exposed in the Baltimore and Ohio Railroad cut through the divide between Sandy Creek and Huff Run (fig. 2). Old state route 8 crosses this cut on a bridge; the new route is located some 1000 feet to the east.

FIGURE 1

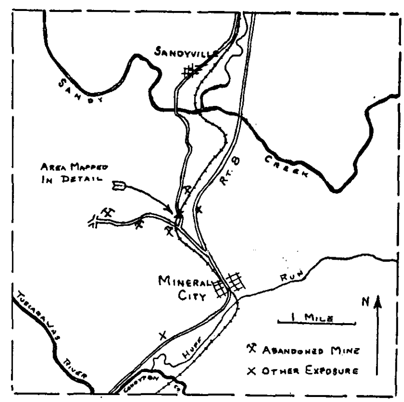

FIGURE 2

FIGURE 1. Index map of Ohio showing location of Tuscarawas County and Sandy Township.
FIGURE 2. Sandy Township, showing localities mentioned in the text. Based on U. S. Geological Survey map of Dover Quadrangle, with corrections.

This exposure was opened when the Cleveland Terminal and Ohio Valley Railroad (now a part of the B & O) was carried into Mineral City (then Mineral Point) about 1880. Since then the steep tilting of the rocks there exposed to view has confused and baffled three generations of geologists. The earliest explanation, proposed by Orton (1884, p. 263), that "a considerable disturbance occurred near the end of the Lower Coal Measure period" appears to suggest a tectonic origin. This is not looked upon with much favor because of the very local nature of the disturbance and the variety of horizons at which it occurs in the vicinity. It has since been relegated to the category of "one of those things" which are found in the Pennsylvanian rocks, are highly disturbing both to the rocks and to the geologist, and are therefore conveniently ignored.

The cut itself is about 1000 feet long and 50 feet deep, and exposures along its sides are still good. They were mapped in the spring of 1950 by Arnold, using the

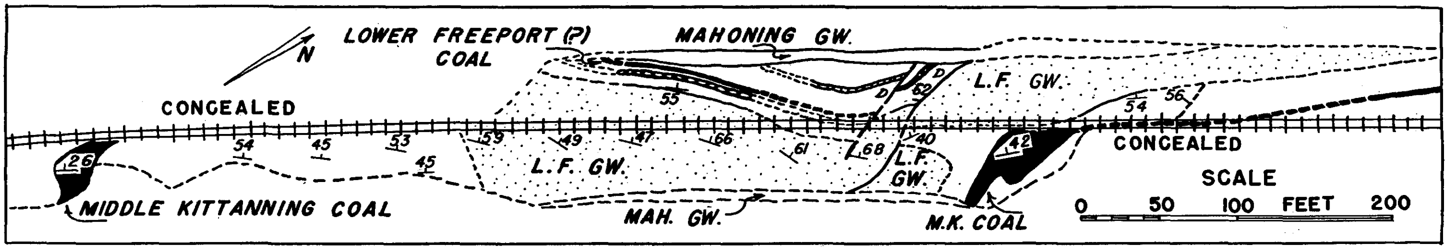

FIGURE 3. Areal geologic map of B. & O. R. R. cut 1 mile northwest of Mineral City, Ohio. D indicates downthrown side of faults. Dips given in degrees. Geology by D. E. Arnold.

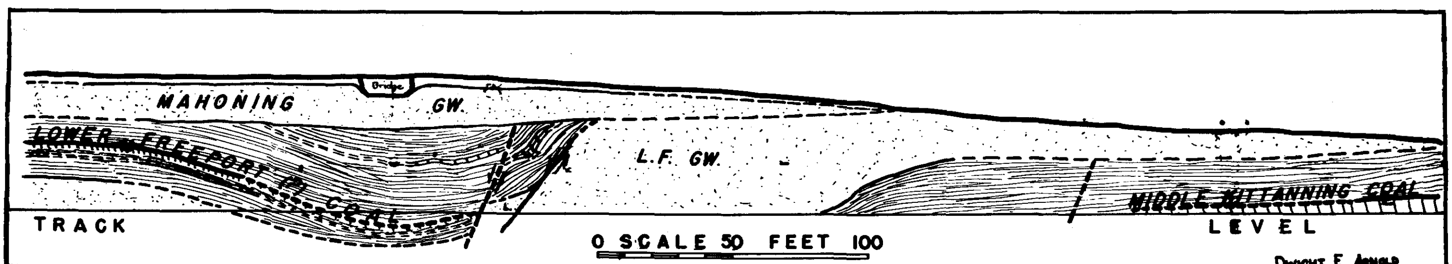

FIGURE 4. Profile of rocks exposed on northwest side of B. & O. R. R. cut. Positions taken from plane table map; elevations measured by hand level. Vertical and horizontal scales the same.

plane table. A stratigraphic section was measured in the spring of 1951 by Gray. The results are illustrated in figures 3–6.

The general form of the structure is that of a small syncline which pitches steeply northwest and is cut by at least three small normal faults. Only one of these is of much displacement. The surface of this fault, the middle one on the map (fig. 3), dips approximately west, and the slip appears to be obliquely down and to the northwest. The smaller faults appear to parallel this one, but are less well exposed.

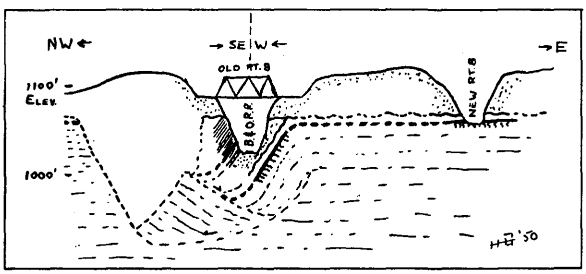

FIGURE 5

FIGURE 5. Sketch cross-section of B. & O. R. R. and new highway cuts, showing observed structure (solid lines) and inferred structure (dotted lines). Vertical exaggeration about five times; dip angles not exaggerated.

FIGURE 6. Columnar section of rocks exposed in B. & O. R. R. cut. All strata below Mahoning graywacke are tilted at angles upt o 66 degrees. Measurement by tape, Brunton compass, and plane table.

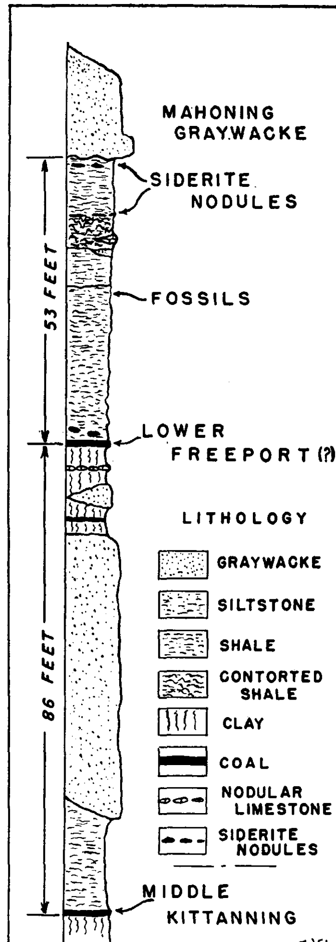

FIGURE 6

The oldest rocks in the cut are the Middle Kittanning coal and underclay. These are exposed in the extremities of the cut with rather moderate dips. Near the center of the cut, however, the dip of this coal is 42 degrees, formerly shown in a miniature flatiron held up by the coal. This unique feature unfortunately disappeared during the severe 1950–1951 winter, probably into the stove of some nearby farmhouse. Stratigraphically above this, mostly near the center and on the northwest wall of the cut, appear the rocks shown in the columnar section (fig. 6), all except the uppermost dipping at angles up to 66 degrees and generally northwest.

The inclined beds are bevelled about half way up the sides of the cut by a massive graywacke of horizontal attitude. This rock is tentatively referred to the Mahoning sandstone (lithologically a graywacke), following the usage in previous reports (Orton, 1884, p. 263). Discontinuity of exposures has prevented the correlation of this unit with certainty.

About half a mile north of the cut in the opening of an old drift mine, the Middle Kittanning coal lies horizontally about 6 feet below the upper graywacke, and to the east, in a portion of the highway cut, the same relationship is found. In fact, throughout the nearby area this rock lies but a few feet above the coal, though the relief at its lower contact is at least 14 feet, as seen in exposures in the highwall of a strip pit about a mile west of the B & O cut.

Truly tectonic folding is not considered likely as a cause of this structure, since such severe contortion could only be the result of a compressional force strong enough to be felt over a much wider area. Furthermore, the shape of the fold differs from those which are clearly tectonic.

Hypotheses which must be entertained regarding the origin of this structure include several of the mechanisms classed as penecontemporaneous or contemporaneous deformation. Classified genetically, these mechanisms may be listed as follows:

1. Tectonic. Slumping of unconsolidated sediments as a result of folding or faulting.
2. Depositional. Sliding on initial dip.
3. Erosional. Slumping into channels, off sea cliffs, etc.
4. Diagenetic. Differential compaction of sediments.
5. Glacial. Contortion of glacial deposits by overriding.

Since the disturbed rocks are not of glacial origin and lie without the glacial boundary, glacial action may be eliminated as a possible cause. Diagenetic folding results in only gentle folds, and may therefore be dismissed also.

Tectonically produced slumping is unlikely as a cause of this structure since the area in general is devoid of strong enough dips to produce sliding and folding of this sort. The regional dip in this area is less than a degree, and no evidence exists that it ever was significantly larger.

The hypothesis of sliding on initial dip is less easily disposed of. It is thought by many geologists that the coals were deposited as essentially horizontal layers, but there is little proof of this. However, the wide variety of sedimentary rocks involved, plus the fact that none of them possess any of the criteria described by Rich (1951) as diagnostic of the clinothem, in which such sliding commonly takes place, are believed unfavorable to this hypothesis.

It is proposed that this structure is the result of slumping of these Pennsylvanian rocks, shortly after their deposition, into the valley of a stream on the outside of an entrenched meander. This was followed by alluviation of the valley, truncation of the slumped beds and removal of some of the horizontal beds by lateral erosion, and burial by later Pennsylvanian sediments.

First there was deposited a sequence of rocks only a part of which remain in this area (fig. 7, stage 1). These included the Lower Freeport (?) coal, 86 feet above the Middle Kittanning, and at least 53 feet of shales and limestones above this coal, the greater part of which is not now found in this vicinity outside of the area of the B & O R. R. cut. These poorly consolidated sediments were cut by a meandering stream to a depth which must have exceeded 150 feet (fig. 7, stage 2). The soft sediments on the undercut bank slumped, bent, and faulted into the valley (fig. 7, stage 3). Some beds were contorted by this process, but most appear to have been sufficiently cohesive to maintain their primary structural characteristics. The fissile character of the dark shales, and the blocky fracture of the coals appear unchanged by the deformation. The valley was then filled, and erosion bevelled the tilted beds and removed most of the adjacent horizontal sediments to within a few feet of the level of the coal. On this surface, as well as in the valley, the Mahoning graywacke was deposited (fig. 7, stage 4). It is thought that the periods of erosion and deposition were not separated by any great length of time, and that both were probably fluvial. A marine origin of the valley is considered possible, but not likely; a subaerial valley appears more readily produced than a submarine canyon, the origin of which would be the subject of some controversy.

The result is shown in a section (fig. 5) which crosses both the railroad and highway cuts. Fracture cleavage in the Middle Kittanning underclay, indicating a relative upward movement of the coal over the clay, and the elevation of the

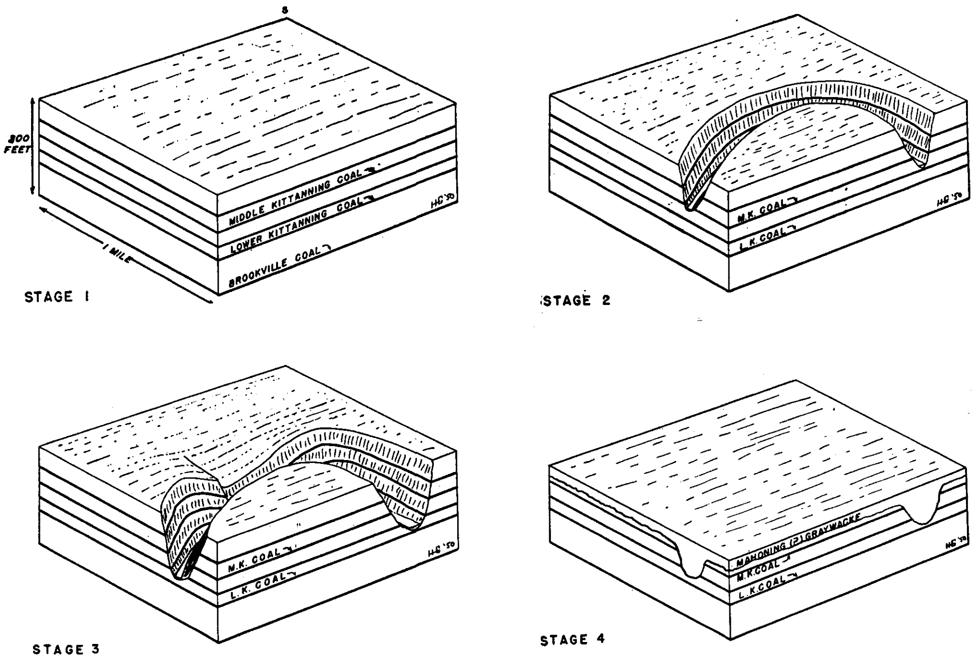

FIGURE 7. Inferred stages in the development of the Mineral City erosional slump structure. All views looking south.

Middle Kittanning coal in the highway cut and in the drift mine to the north, tend to confirm this view of the structure. Because of this disturbance, the immediate area has not been strip mined, and old drift mines nearby have not been successful. Deep gas wells both to the east and to the west of the section illustrated have reported no coal.

Similar structures have been mapped by Ferm (1948) near Brookville, Pa., where they are associated with thickened "shoestrings" of graywacke which have a dendritic pattern and appear to represent the old filled valleys. The Brookville area has been extensively strip mined and the continuity of the exposures there leaves little doubt of the origin of the structures. Channels at the base of what appears to be the Mahoning graywacke are known in the Mineral City region, but careful tracing and mapping of them has not been possible up to the present writing.

Similar structures are found elsewhere in the Mineral City region. They were long ago reported in several of the old drift mines for coal, both here and at nearby Zoar. In one mine the Lower Kittanning coal was reported to have been folded upon itself and thickened from its usual 3 to as much as 13 feet (Newberry, 1878, p. 65). A half mile west of the B & O cut the Lower Kittanning coal is cut out in a strip mine against a bed of steeply dipping graywacke, probably the same one found tilted in the railroad cut. The tilted beds dip northwest toward the slip surface, and the coals in the slumped block (two coals are seen) roll irregularly. A mile southwest of Mineral City, the Lower Kittanning coal is again cut by a similar structure, well exposed to view. In this case the tilted beds consist of unidentified varicolored siltstones dipping southeast against a northwest dipping slip surface—a typical slump structure.

Nor are such structures confined to this region. Other examples, some less spectacular, are known at Dover Dam, East Sparta, East Canton, North Benton, and Lowellville, Ohio. They are known in West Virginia, near Wellsburg, and in Pennsylvania, at Rochester and Kittanning as well as at Brookville. These involve rocks of the Pottsville, Allegheny, and Conemaugh formations, but the strata associated with the Kittanning Coals appear to be the most profoundly affected.

Somewhat similar structures have also been noted in the Fort Union formation of North Dakota (Townsend, 1950; Benson and Golder, 1950) and in Tertiary formations of South Dakota (Toepleman, 1923). All of these disturbances involve lignitic deposits, but those in North Dakota have been referred to a tectonic origin.

Delineation of these structures is of practical importance in coal mining, for they disturb and displace the coals and weaken the rock structure in such a way as to make mining physically and financially risky. Distinction of these from truly tectonic structures is important in the search for oil and gas, as they rarely extend to any great depth. Such a structure might well form a suitable trap for petroleum, but its prediction in the subsurface would be difficult.

Detailed mapping of slump structures may yield more information of academic or practical interest on the pattern and habits of the agents of erosion and deposition during Pennsylvanian time. They are worth more intensive study than they have as yet been given. The authors would welcome additional information on such features in Ohio and elsewhere.

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